Massively Expanded NEA Accessibility via Microwave-Sintered Aerobrakes

Completed Technology Project (2017 - 2018)

Project Introduction

The two fundamental prerequisites for large-scale economic use of space resources are: in-space manufacture of propellants from nonterrestrial bodies, and in-space manufacture of heat shields for low-cost capture of materials into Earth orbit. The former has been the subject of recent NIAC investigations. The latter would expand by a factor of 30 to 100 time the number of asteroids from which resources could be returned cost-effectively to Earth orbit. With vastly larger populations from which to choose, return opportunities will be much more frequent and targets can be selected where operations would be highly productive, not merely sufficient. The feedstocks for manufacture of life-support materials and propellants are found on C-type near-Earth asteroids, which have high concentrations of hydrogen, carbon, nitrogen, oxygen and sulfur. The total abundance of readily extractable (HCNOS) volatiles in the CI chondritic meteorite parent bodies (C asteroids) is roughly 40% of the total meteorite mass. Further, the residue from extraction of volatiles includes a mix of metallic iron (10% of total mass), iron oxide and iron sulphides (20% as Fe) plus 1% Ni and ~0.1% Co.##We propose to use microwave heating to 1) expedite selective release of H2O vapor from heated C asteroid solids, and 2) sinter highly outgassed refractory asteroidal material to make heat shields for aerocapture at Earth return. We will study both processes experimentally using C-type asteroid simulant made by Deep Space Industries under contract with NASA, and study the logistics of retrieval of asteroid materials to Earth orbit using these aerobrakes. The result will be a uniquely propellant-rich deep space exploration architecture with faster timetables enabled by the greater engineering and safety margins allowed by abundant propellant.

Anticipated Benefits

The result of this research will be a uniquely propellant-rich deep space exploration architecture with faster timetables enabled by the greater engineering and safety margins allowed by abundant propellant

Massively Expanded NEA Accessibility via Microwave-Sintered Aerobrakes. Credits: John Lewis

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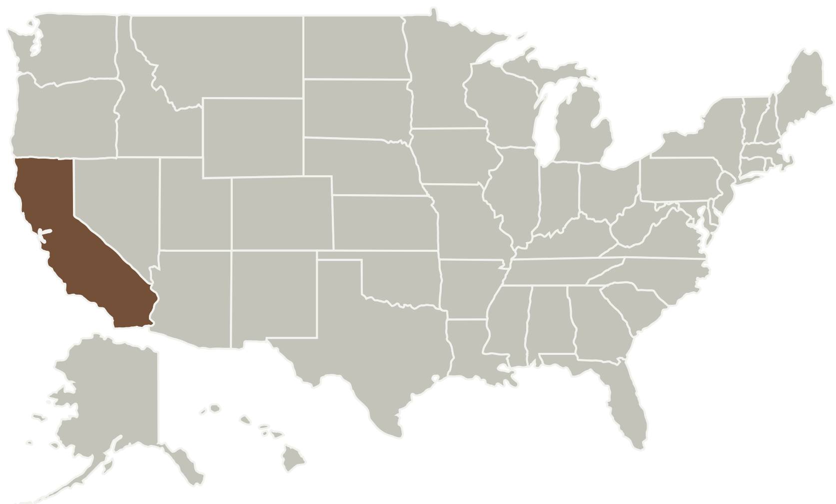
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Deep Space Industries, Inc.	Lead Organization	Industry	San Jose, California
The University of Tennessee-Knoxville(UT-K)	Supporting Organization	Academia	Knoxville, Tennessee

Primary U.S. Work Locations
California

Project Transitions

April 2017: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Deep Space Industries, Inc.

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

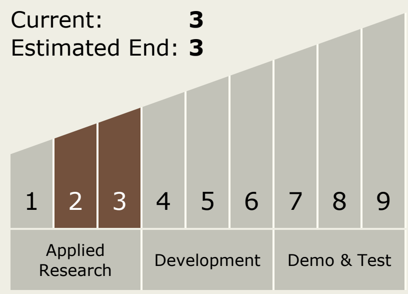
Eric A Eberly

Principal Investigator:

John R Lewis

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



January 2018: Closed out

Closeout Summary: The availability of a wide range of natural resources amon g the near-Earth asteroid (NEA) population offers the opportunity to utilize these resources in the service of making access to most of the Solar System much eas ier than any classical approach which relies solely upon structural, heat-shield, li fe support and propellant materials lifted from Earth. We have concentrated our attention on the two main factors that influence the application and utility of in s itu aerobrake manufacture on near-earth asteroids. The first of these is the use of microwave sintering in the fabrication of aerocapture heatshields for retrieval of asteroidal materials into Earth orbit; the second is assessment of the perform ance of these aerocapture devices, including making very large numbers of NEA s accessible as sources of essential materials to support space exploration and e xploitation. The ability to provide propellants, life support materials, or structura l metals in space is dependent upon identifying volatile-rich carbonaceous astero ids in orbits that are energetically accessible for outbound spacecraft. They must also be accessible for retrieval of returned material into Earth orbits that are wel l situated for launching such missions. The general NEA population is well suited to providing these materials; the subset of NEAs with the easiest access from (a nd to) Earth are the small population of bodies with heliocentric orbits that are c losest to Earth and have the lowest orbital eccentricity (the Aten family). These bodies are generally quite small and faint, with diameters rarely larger than 100 meters. They also typically have long synodic periods of tens of years, which ma ke both Earth-based astronomical studies and spacecraft launch opportunities in frequent and challenging. As a result of these difficulties, Earth-based spectral c haracterization of these small bodies remains very incomplete; in the absence of spectral evidence for an economically attractive composition, there would be littl e incentive to launch exploratory spacecraft to such asteroids. These bodies also experience higher temperatures than most NEAs because they are 1) closer to t he Sun, 2) are much smaller, and 3) have low-eccentricity orbits that do not pro vide lengthy cold-soak conditions near aphelion. There is general reason to concl ude that these bodies must have experienced more severe solar heating and out gassing than other NEAs with more typical (distant and eccentric) orbits. Even p roducing evidence for a significant population of dark (low albedo) bodies in nea r-Earth orbits would not demonstrate that they are attractive sources of volatile s; convincing proof that water is present would require detection of the 3 μm wa ter absorption feature, which requires such extreme sensitivity that tiny, faint, a nd rarely-visible asteroids would be unpromising observation targets. A compen satory benefit is that such bodies provide lower encounter velocities with Earth, so that capture into Earth orbit by a single lunar flyby is possible. The broader p opulation of NEAs, typically of much larger size, much larger aphelion distances (mostly Apollo asteroids), and with much shorter synodic periods, provides thou sands of attractive targets that require larger return velocities. Many of these as teroids are kilometers in diameter and come with strong spectral data for the pr esence of water. It is this expectation that the target asteroid masses and comp ositions will direct our attention to Apollo asteroids rather than Atens that makes it necessary (and profitable) to consider higher v_∞ approaches to Earth. Approa ch velocities up to 5 km/s are considered in this report and would vastly increas e the number of accessible NEAs. Such high approach velocities require a means of energy dissipation during capture that exceeds the ability of a lunar swingby t o effect capture. Purely propulsive capture maneuvers become prohibitively exp ensive at such high approach velocities, suggesting aerobraking as an approach that minimizes propellant use and has the additional benefit of making the mate rial of the used aerobrake available for processing in the target Earth orbit. Phas

Technology Areas

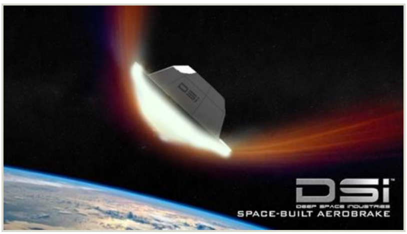
Primary:

- TX07 Exploration Destination Systems
  - └ TX07.1 In-Situ Resource Utilization
    - └ TX07.1.2 Resource Acquisition, Isolation, and Preparation

Target Destination

Others Inside the Solar System

Images



Project Image
Massively Expanded NEA Accessibility via Microwave-Sintered Aerobrakes. Credits: John Lewis
(https://techport.nasa.gov/image/102229)

Links

NASA.gov Feature Article
(https://www.nasa.gov/directorates/spacetech/niac/2017_Phase_I_Phase_II/Microwave_Sintered_Aerobrakes)